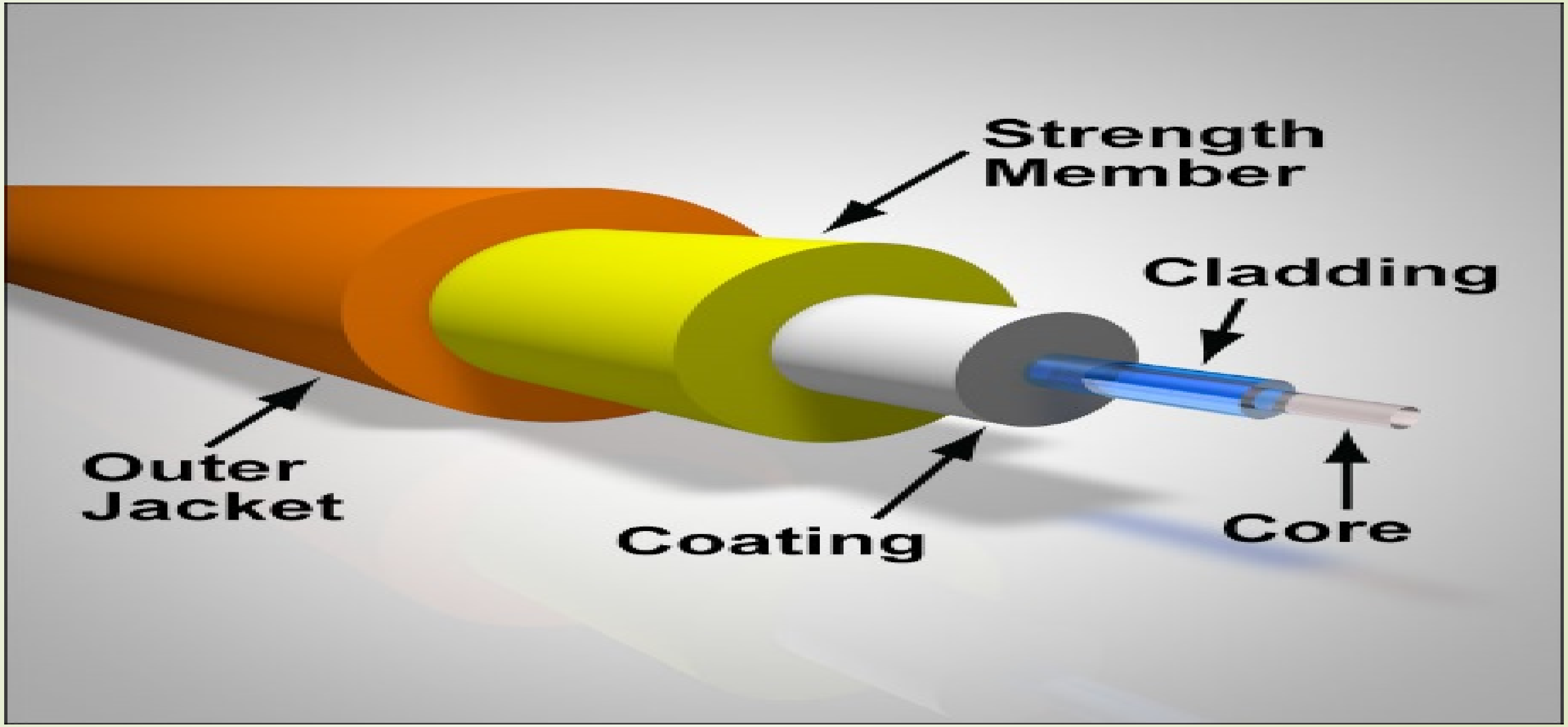
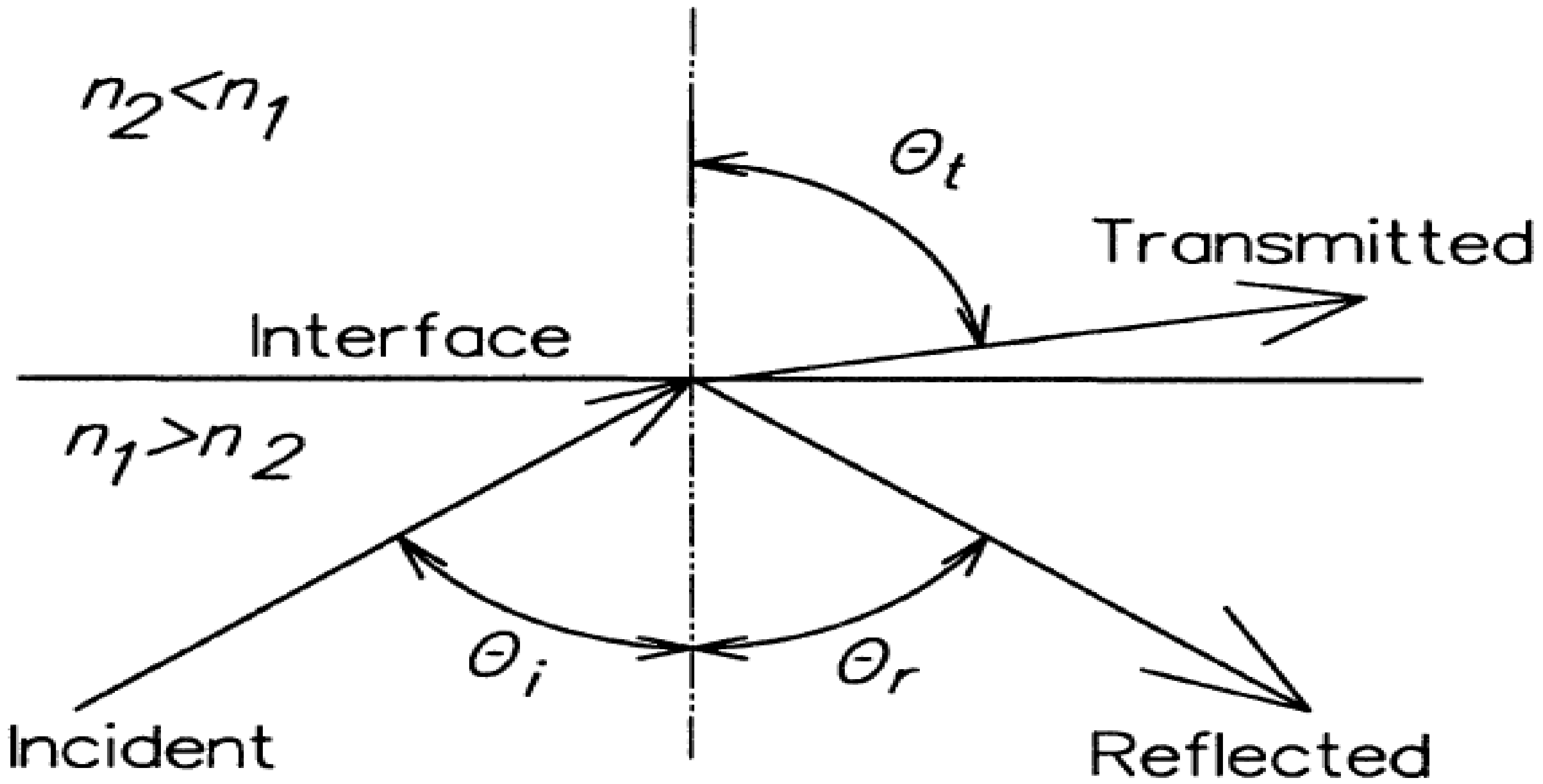
The Optical Fiber

Chapter 2

Optical fiber structure



Refraction and Reflection



Laws

	$n = \frac{c}{v}$	**(1)**
	$n_1 \sin \boldsymbol{\theta}_i = n_2 \sin \boldsymbol{\theta}_t$ **(Snell's law)**	**(2)**
	$\theta_i = \theta_r$ (Law of reflection)	(3)
	Critacal Angle $\boldsymbol{\theta}_i = \boldsymbol{\theta}_c = \sin^{-1}(\frac{n_2}{n_1})$	**(4)**

Δ is the *fractional change in the index of refraction*, given by

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} \approx \frac{n_1 - n_2}{n_1} .$$

$$n_2 \approx n_1(1 - \Delta)$$

Example

Example: (a) Assuming that n_2 is 1% smaller than n_1, find n_2 if $n_1 = 1.45$.

<u>Solution:</u> Since n_2 is 1% smaller than n_1, it is 99% of n_1, so we have

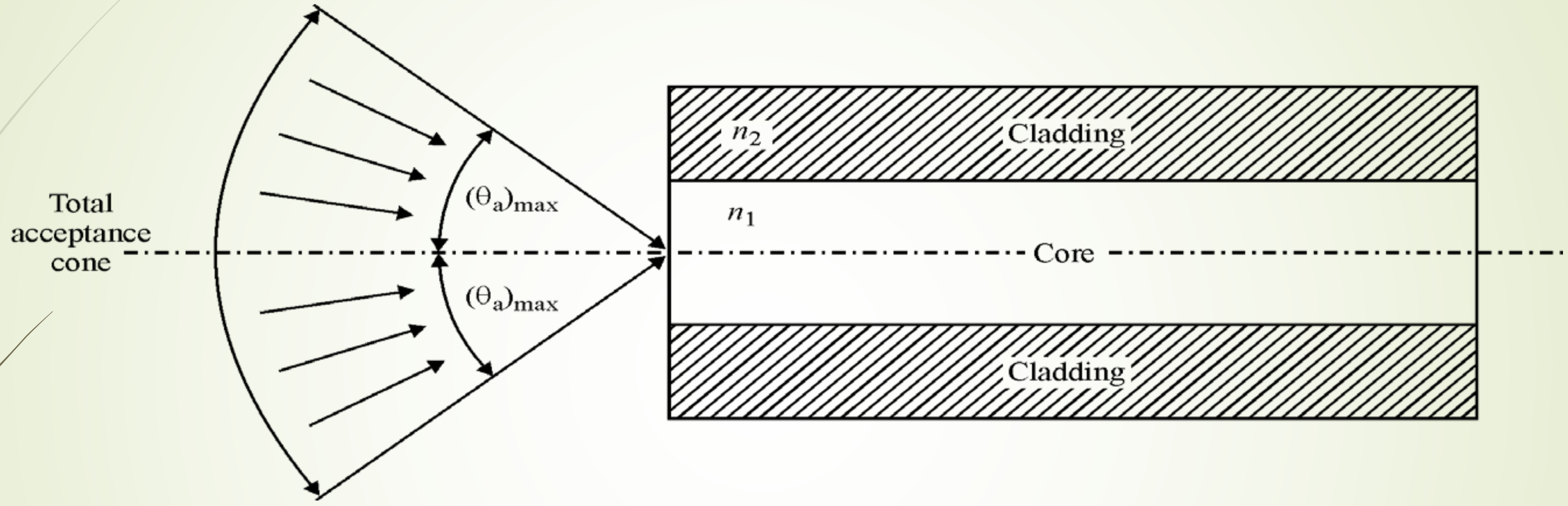
$$n_2 = 0.99 n_1 = 0.99 \times 1.45 = 1.435\,.$$

(b) Find the value of the critical angle.

<u>Solution:</u> The critical angle is found from

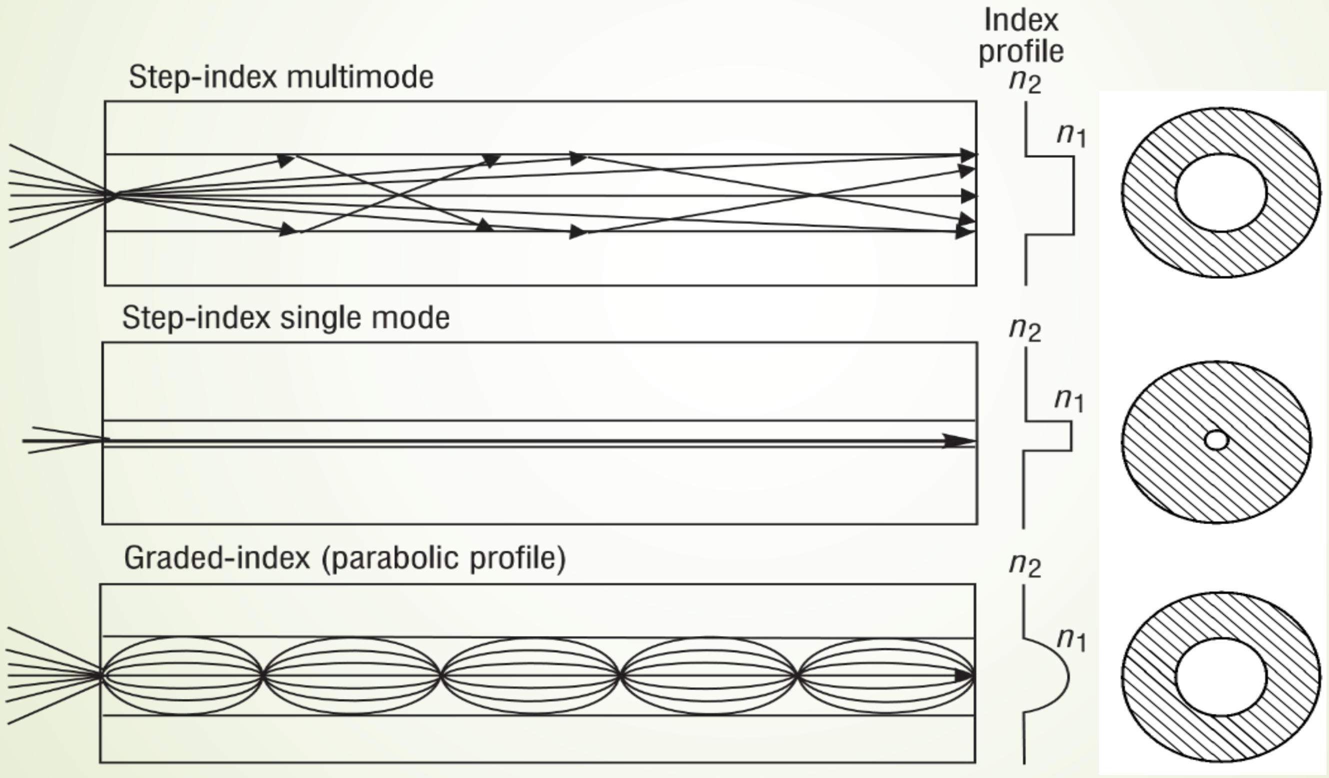
$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{0.99 n_1}{n_1}\right) = \sin^{-1}(0.99) = 81.9^\circ\,.$$

Numerical Aperture



$$N.A. = \sin(\theta_a)_{max} = \sqrt{n_1^2 - n_2^2} = n_1\sqrt{2\Delta}$$

Types of Fibers w.r.t their **Refractive Index profiles**



<u>Comments</u>

- Large N.A.
- Easy coupling
- Modal dispersion
- Lower data rates
- Shorter distances

- Small N.A.
- Coupling more difficult
- No modal dispersion
- High data rates
- Long distances

- Large N.A.
- Easy coupling
- Less modal dispersion
- Good compromise between multimode and single-mode fiber

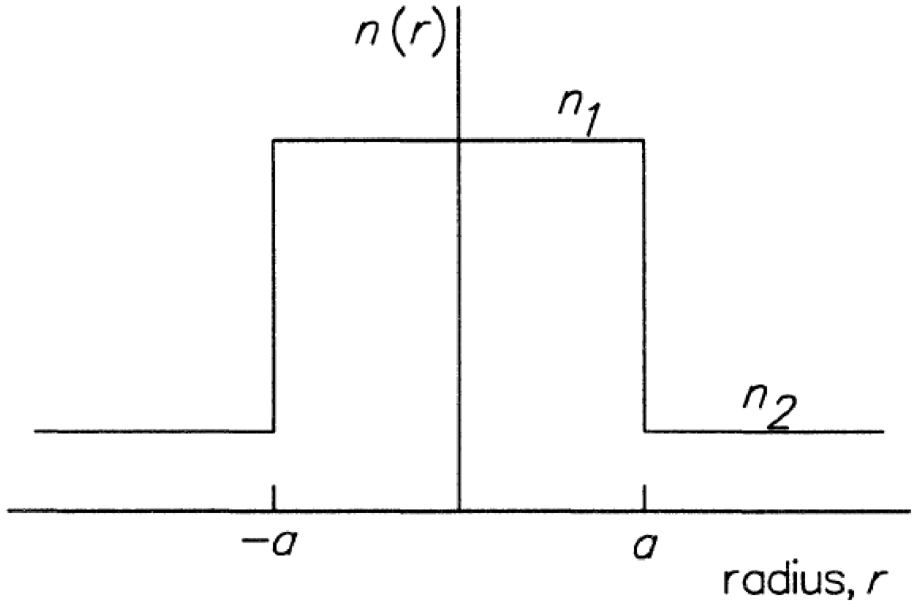


Figure 2.3 Refractive index profile of a step-index fiber.

Type	core diam. μm	cladding diam. μm	Δ	Application
8/125 single-mode	8	125	0.1% to 0.2%	Long distance, high data rate
50/125 multimode	50	125	1% to 2%	Short distance, moderate data rate
62.5/125 multimode	62.5	125	1% to 2%	Local area networks
100/140 multimode	100	140	1% to 2%	Local area networks, short distance

Table 2.1 Representative parameters for standard fibers.

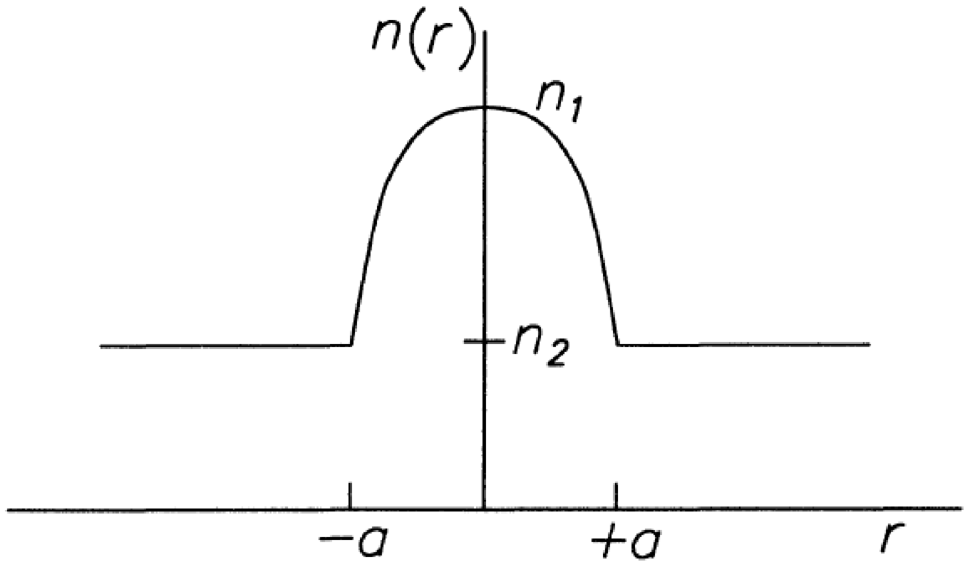


Figure 2.10 Index of refraction vs. radial position for a graded-index fiber.